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ONR Basic Research Program: Summary and Bibliographies

Annual Reports under Grant N00014-90-J-1366, FY92 and FY93

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13. ABSTRACT (Maximum 200 words)

The Office of Naval Research (ONR) sponsors the Basic Research Program, a discretionary grant program for the purpose of giving university laboratory directors freedom to develop and apply their resources to basic research problems of naval relevance, which may not be known or appreciated by others in the community. Program guidelines include (1) involvement of students and faculty and (2) initiation of research in areas that could transition into either core or special research initiative (SRI) programs at ONR.

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1. INTRODUCTION

The subject grant was originally issued on 1 October 1989 in response to Applied Research Laboratories, The University of Texas at Austin (ARL:UT), proposal P-1502, dated 17 August 1989.[1] This grant was funded out of the Office of the Chief of Naval Research (ONR) discretionary block for support of this laboratory as well as the following laboratories: Applied Research Laboratory, Pennsylvania State University (ARL/PSU); Applied Physics Laboratory, University of Washington (APL:UW); and Marine Physics Laboratory, Scripps Institution of Oceanography, University of California at San Diego (MPL:SIO:UCSD). This block was originally administered by ONR Code 1125AO, Dr. Marshall Orr and Mr. Marvin Blizard. Dr. Mohsen Badiey succeeded Dr. Orr in 1993 and Dr. Jeffrey Simmon took over from Mr. Blizard in 1994. The purpose of the discretionary grant program is to give the laboratory directors freedom to develop and apply their resources to basic research problems of naval relevance, which may not be known or appreciated by others in the community. The guidelines of the program include (1) involvement of students and faculty and (2) initiation of research in areas that could transition into either core or special research initiative (SRI) programs at ONR.

Annual reports for activities under this grant for FY90 and FY91 have been published.[2]

The grant was renewed on 13 December 1991 for FY92, in response to ARL:UT proposal P1555, dated 22 August 1991,[3] which added $348K. Support for FY92 was for seven research problems, funded as shown in Table 1.1. This includes two modifications of the grant, one issued on 28 March 1992 in response to ARL:UT proposal P-1578,[4] dated 14 February 1992, and another issued on 31 July 1992 in response to ARL:UT proposal P-1587,[5] dated 7 May 1992. These modifications added $18.5K to the grant.

Table 1.1
Support for FY92

Research Project	Principal Investigator	Funding
Excess Reflection Loss over Gassy Sediments	Dr. N. Chotiros	$90K
Basic Research for the Plasma Sound Source	Dr. R. Rogers	$50K
Toward an Expert Database System	Dr. D. Brant	$80K
Structural Acoustics	Dr. R. Stearman	$23K
High School Apprenticeship Program	Dr. T. Muir	$32K
Electromagnetic Properties of Sea Ice	Dr. G. Bust	$40K
Bubbles and the Generation of Ocean Noise	Dr. E. Vishniac	$33K
Plasma Sound Source Bubble Interaction Experiment	Dr. R. Rogers	$10K
High School Apprenticeship - Long Term	Dr. T. Muir	$8.5K

The subject grant was again renewed on 10 November 1992 in response to ARL:UT proposal P-1593, dated 17 July 1992,[6] providing $370K of support for FY93 on six research projects, funded as shown in Table 1.2. This includes a modification of the grant, issued on 23 September 1993 in response to ARL:UT proposal P-1603,[7] dated 8 February 1993, which added $8.5K to support the long-term high school apprenticeship program.

Table 1.2
Support for FY93

Research Project	Principal Investigator	Funding
Excess Reflection Loss over Gassy Sediments	Dr. N. Chotiros	$85K
High School Apprenticeship Program	Dr. T. Muir	$35K
Electromagnetic Properties of Sea Ice	Dr. G. Bust	$55K
Combustive Sound Source	Mr. P. Wilson	$85K

Table 1.2 (cont'd)

Research Project	Principal Investigator	Funding
Deafening of Fish by Active Sonar Irradiation	Dr. T. Muir	$25K
Distributed Visual Simulation	Dr. D. Fussell	$85K
High School Apprenticeship Program - FY94	Dr. T. Muir	$8.5K

FY92 and FY93 statistics on projects, students, faculty, etc., are shown in Table 1.3.

Table 1.3

ONR Basic Research Program at ARL:UT

Purpose:

- Provide seed money - new 6.1 research
- Support UT professors and students on problems of naval relevance
- Support High School Apprenticeship Program

Administration:

- Dr. Mohsen Badiey, ONR 1125 OA
- Individual ONR project officers
- ARL:UT IR&D Coordinator

	FY89	FY90	FY91	FY92	FY93
$K	133	299	310	348	370
No. of Active Projects	11	5	6	7	8
No. of Students	11	5	6	7	6
No. of Faculty	9	4	5	6	4

2. RESEARCH RESULTS

The following bibliographical information summarizes the scientific results produced under this grant.

2.1 ARCHIVAL PUBLICATIONS

Bibliographical data are presented here, as well as the abstract of each paper that appeared in refereed journals. Also included are publications that have been submitted but are still in the journal editing process.

1. Chotiros, N. P., and M. Stern, "Reflection and Propagation Loss over Porous Sediments," *J. Acoust. Soc. Am.* **93**(4), pt. 2, 2397.

   A full wave acoustic propagation model in a stratified viscoelastic medium (H. Schmidt and F. B. Jensen, J. Acoust. Soc. Am. **77**, 813-825 (1985)) was combined with Biot's theory for propagation and reflection in a porous medium (Stern et al., J. Acoust. Soc. Am. **77**, 1781-1788 (1985)) to produce a model of acoustic propagation in a stratified porous medium. Sample results were compared with a normal mode model (T. Yamamoto, J. Acoust. Soc. Am. **73**, 1587-1596)). The model was extended to account for the effect of gas bubbles in the pore fluid (J. A. Hawkins and A. Bedford, J. Acoust. Soc. Am. Suppl. 1 **88**, S131 (1990)). Significant differences between viscoelastic, poroelastic, and gassy poroelastic models were investigated.

2. Cook, Jeffrey A., Randy M. Roberts, and Robert L. Rogers, "A Spark Generated Bubble Model with Semi-Empirical Mass Transport," J. Acoust. Soc. Am., in press.

   This paper describes the time evolution of bubbles generated by underwater electrical discharges. The oscillations of these high temperature vapor and plasma bubbles generate acoustic signatures similar to the signatures generated by air guns, underwater explosions, and combustible sources. A set of model equations is developed that allows the time evolution of the bubble generated by a spark discharge to

be calculated numerically from a given power input. The acoustic signatures produced by the model were compared to previously recorded experimental data. The model was found to agree over wide ranges of energy and ambient pressure on several characteristic values of the acoustic signatures. The bubble period in particular matched very well between model and experiment, indicating that the total energy losses predicted by the model over the oscillation of the bubble were approximately correct, though no reliable information is gained about the relative magnitudes of the individual energy loss mechanisms examined. The bubble period and the minimum rarefaction pressure are found to depend on depth, while the peak pressures in the expansion and collapse pulses and the acoustic energy in the expansion pulse are not found to depend on depth.

3. Roberts, Randy M., Jeffrey A. Cook, Austin M. Gleeson, Thomas A. Griffy, and Robert L. Rogers, "The Energy Partition of Underwater Sparks," submitted to J. Acoust. Soc. Am., October 1994.

Underwater sparks have long been used by the geophysical prospecting community as a source of intense low-frequency sound. While bubble hydrodynamic models are well developed, the mechanism of transferring energy from the thermal power input, through the various energy conversion channels, to the work done by the bubble, has not been adequately studied. In this work an *ab inito* model of the bubble dynamics, including blackbody ablation, ionization, dissociation, and radiative transport, is developed. This model is a first step in enumerating the important physical mechanisms within bubbles generated by underwater sparks. The predictions of this model are compared with experimental results.

4. Wilson, Preston S., Janet L. Ellzey, T. G. Muir, "Experimental Investigation of the Combustive Sound Source," submitted to the IEEE Journal of Oceanic Engineering, August, 1994.

In this paper, we describe a unique low frequency underwater sound source called the Combustive Sound Source (CSS). In this device, a

combustible gas mixture is captured in a combustion chamber and ignited with a spark. The ensuing combustion produces expanding gases which, in turn produce high intensity, low frequency acoustic pulses. With high-speed motion pictures of the CSS event, we relate the motion of the bubble to the acoustic waveform. We also compare the measured first bubble period in the CSS pressure signature with the predictions of the Rayleigh-Willis equation, including the dependence of the radiated acoustic waveform on the volume and depth of the bubble. Measurements of the first bubble period agree with Rayleigh-Willis theory in trend, but not in absolute value. In addition, we discuss the variation of the acoustic output with the fuel/oxygen mixture. Finally, several other factors that affect the acoustic output of CSS are discussed. These include the shape of the CSS combustion chamber, the ignition source, the type of oxidizer and fuel, and the presence of high-frequency components.

2.2 NON-ARCHIVAL PUBLICATIONS

Bibliographical data and abstracts for papers that appeared in non-refereed publications, such as the proceedings of symposia, etc., are presented here, along with the dates, location, host organization, and special topic of the publication.

1. O'Donnell, R. B., R. O. Stearman, W. E. Brown, E. J. Powers, and G. R. Wilson (1991). "Factors Contributing to the Nonlinear Acoustic Response in Fluid Structural Interactions on a Thin Cylindrical Shell," Proceedings of the 9th International Modal Analysis Conference.

   The results of a theoretical analysis and an experimental study are presented for the nonlinear vibration and acoustic response of a thin cylindrical shell structure. The generalized equations of motion for the thin shell, without preload, demonstrate a cubic type of nonlinearity of the geometric stiffness type. An experimental acoustic response study of an unstressed, excited thin cylindrical shell, however, revealed, through higher order signal processing techniques, a dominant presence of a quadratic type of nonlinearity. Following the theoretical development of

Liu and Arbocz, geometric imperfections, initial preload, and orthogonal stiffening were then introduced into the nonlinear shallow shell equations. A dynamic solution of the resulting generalized equations was then shown to produce quadratic type nonlinear contributions to the overall calculated shell displacement response. That is, good agreement was obtained between theory and experiment when the effects of geometric imperfections were included in the theoretical modeling of the shell. While the use of an active control feedback system was beneficial in silencing the acoustic response from the fundamental tones of the shell vibration, significant spillover of the actively controlled response was observed in the higher order spectral domain.

2. O'Donnell, R. B., R. O. Stearman, W. E. Brown, E. J. Powers, and G. R. Wilson (1991). "Factors Contributing to the Nonlinear Acoustic Response in Fluid Structural Interactions on a Thin Cylindrical Shell," presented at the 9th and 10th International Modal Analysis Conference, San Diego, CA, 3-7 February 1992.

The results of a theoretical analysis and an experimental study are presented for the nonlinear vibration and acoustic response of a thin cylindrical shell structure. The generalized equations of motion for the thin shell, without preload, demonstrate a cubic type of nonlinearity of the geometric stiffness type. An experimental acoustic response study of an unstressed, excited thin cylindrical shell, however, revealed, through higher order signal processing techniques, a dominant presence of a quadratic type of nonlinearity. Following the theoretical development of Liu and Arbocz, geometric imperfections, initial preload, and orthogonal stiffening were then introduced into the nonlinear shallow shell equations. A dynamic solution of the resulting generalized equations was then shown to produce quadratic type nonlinear contributions to the overall calculated shell displacement response. That is, good agreement was obtained between theory and experiment when the effects of geometric imperfections were included in the theoretical modeling of the shell. While the use of an active control feedback system was beneficial in silencing the acoustic response from the fundamental tones of the shell vibration,

significant spillover of the actively controlled response was observed in the higher order spectral domain.

3. Brant, David A., and Daniel P. Miranker, "Index Support for Rule Activation," Proceedings of the 1993 ADM SIGMOD International Conference on Management of Data, Washington, DC, May 26-28, 1993.

   Integrated rule and database systems are quickly moving from the research laboratory into commercial systems. However, the current generation of prototypes are designed to work with small rule sets involving limited inferencing. The problem of supporting large complex rule programs within database management systems still presents significant challenges. The basis for many of these challenges is providing support for rule activation. Rule activation is defined as the process of determining which rules are satisfied and what data satisfies them. In this paper we present performance results for the DATEX database rule system and its novel indexing technique for supporting rule activation. Our approach assumes that both the rule program and the database must be optimized synergistically. However, as an experimental result we have determined that DATEX required very few changes to a standard DBMS environment, and we argue that these changes are reasonable for the problems being solved. Based on the performance of DATEX we believe we have demonstrated a satisfactory solution to the rule activation problem for complex rule programs operating within a database system.

4. Chotiros, Nicholas P., "Inversion and Sandy Ocean Sediments," NATO Conference Proceedings, Full Field Inversion Methods in Ocean and Seismic Acoustics, 27 June -1 July 1994, SACLANT Undersea Research Centre, La Spezia, Italy (in press).

   Inverting the sediment acoustic wave speed from its acoustic reflection coefficient, using viscoelastic wave theory, can lead to gross errors. This can be demonstrated by simple measurements. The reflection coefficient is dependent on the acoustic impedances of the two media on either side of an interface. Under the viscoelastic wave theory, the impedance of

each medium is determined solely by its density and sound speed. Given the measured values of sound speed and density of both water and water-saturated sand, the reflection coefficient may be predicted. It is found, however, that, for sandy sediments, this value is at odds with the directly measured value of reflection coefficient. The data is drawn from *in situ* measurements of reflection coefficient at 12 kHz and 3.5 kHz, and from analyses of core samples taken simultaneously, collected jointly under the MCM Tactical Environmental Data System Project and the Coastal Benthic Boundary Layer Special Research Project. The explanation lies in the theory of wave propagation in porous media. Numerical examples from real sediments will be given.

Similarly, the procedure of inverting the measured value of reflection coefficient for either sediment classification or propagation modeling purposes is subject to the same pitfall. Using a viscoelastic wave theory for shallow water acoustic propagation, it can be shown that the predicted sound field, based on inversion of the reflection coefficient measurement, will be different from that based on direct sediment sound speed measurement. However, neither is correct. For the correct sound field, it is necessary to employ a propagation model that properly takes the poro-elastic property of the sediment into account. Results from a laboratory experiment in which a shallow water sound channel was constructed over a sandy sediment serve to illustrate the problem. The data are compared with the OASES model and a version of the OASES model that has been modified to include Biot's equation for a poroelastic sediment.

5. Fussell, D. S., J. Park, and M. Pandey, "Following Footprints of Reality," Proceedings of the First Pacific Conference on Computer Graphics and Applications, August 1993.

6. Fussell, D. S., G. Lai, and D. F. Wong, "HV/VH Trees: A New Spatial Data Structure for Fast Region Queries," Proceedings of the 30th Annual Design Automation Conference, June 1993.

7. Fussell, D. S., R. Read, and A. Silberschatz, "System Wide Multiresolution," Proceedings of the International Workshop on Next Generation Information Technologies and Systems, June 1993.

8. Fussell, D. S., and W. Xu, "Constructing Solvers for Radiosity Equation Systems," Proceedings of the Fifth Eurographics Workshop on Rendering, June 1994.

9. Fussell, D. S., and W. Xu, "A Fast Solver of Radiosity Equation Systems," Proceedings of the Second Pacific Conference on Computer Graphics and Applications, August 1994.

2.3 COMPLETED DISSERTATIONS AND THESES

Bibliographical and biographical information on these academic documents is presented here. It should be noted that each of the graduates is a U.S. citizen, and each is a potential candidate for a leadership role in the conduct of future naval research and development.

1. Fox, Douglas J. (M.S., Aerospace Engineering, 1992). "Higher Order Spectral Investigations of Nonlinear Transverse Vibrations of Circular Rings."

2. Brant, David A. (Ph.D., Computer Science, 1993). "Inferencing on Large Data Sets."

3. Cook, Jeffrey Alan (Ph.D., Physics, 1993). "Interaction of Multiple Spark-Generated Bubbles in a Compressible Liquid."

4. Lamb, James L., III (Ph.D., Aerospace Engineering, 1993). "An Investigation of Small Amplitude Wave Interactions in Parametrically Excited Periodic Beams."

5. Roberts, Randy M. (Ph.D., Physics, 1993). "The Energy Partition of Underwater Sparks."

6. Wilson, Preston S. (M.S., Mechanical Engineering, 1994). "The Combustive Sound Source."

2.4 DISSERTATIONS AND THESES IN PROGRESS

One project was initiated under the subject contract and is listed below.

1. Till, Paul D. (Aerospace Engineering). "An Investigation of Wave Number Interactions in the Non-Linear Vibrations of Circular Rings."

2.5 PAPERS PRESENTED AT MEETINGS

Under the subject contract, one paper was prepared and presented at a meeting. The title, author, and meeting data follow. This listing does not include papers presented at meetings which have subsequently been issued as archival papers. Almost all such presentations eventually are issued as archival papers such as those listed in Sec. 2.1. The presentation of scientific papers at meetings is a give-and-take process that enables the authors to receive criticism, comments, and an exchange of information that sharpens the work perspective and its ultimate relevance, prior to submission as an archival contribution.

1. Fox, Douglas J. (1991). "The Effects of Geometric Imperfections and Radial Preloading on the Nonlinear Transverse Vibrations of Circular Rings," presented at the 122nd Meeting of the Acoustical Society of America, Houston, TX, 4-8 November 1991.

2.6 ARL:UT REPORTS

In addition to the archival papers, dissertations, theses, and other highly valued scientific documents cited above, there is a very real and important need for the publication of a variety of reports that are useful in the conduct of work.

1. Wilson, Preston, S. (1994). "The Combustive Sound Source," Applied Research Laboratories Technical Report No. 94-9 (ARL-TR-94-9), Applied Research Laboratories, The University of Texas at Austin.

2. Cook, Jeffrey A. (1993). "Interaction of Multiple Spark-Generated Bubbles in a Compressible Liquid," Applied Research Laboratories Technical Report No. 93-10 (ARL-TR-93-10), Applied Research Laboratories, The University of Texas at Austin.

3. Roberts, Randy M. (1993). "The Energy Partition of Underwater Sparks," Applied Research Laboratories Technical Report No. 93-9 (ARL-TR-93-9), Applied Research Laboratories, The University of Texas at Austin.

2.7 DoD SCIENCE AND ENGINEERING APPRENTICESHIP PROGRAM

The purpose of the apprenticeship program is to provide outstanding recent high school graduates with hands-on experience in a stimulating research environment and encourage them to pursue careers in the science and engineering disciplines, particularly in those areas related to the needs of the Department of Defense. Students were selected for this program on the basis of their academic records, scholastic aptitude test results, applications, and references from their teachers. Each student was assigned to a research project to be performed under the supervision of a research staff member at ARL:UT. At the end of the apprenticeship in mid-August, students gave oral presentations, using visual aids, for the laboratory's directors, and prepared short technical papers summarizing their project results. The annual reports included technical papers by the following student authors, whose abstracts are also included.

<u>1992 Participants</u>

Mark Adkins	Series Spark Gap Arrays
Erik Frank	Testing and Evaluation of the Wesmar HD 670-8MCM Sonar System
Scott Holliday	Development and Testing of Stereo Sonar
Cassandra Jordan	Graphical User Interface Development for the Fire Support Automated Test System
Steven Lefler	Alternate Focusing Fluids for Use in Acoustic Target Spheres
Colby Leider	Test Data File Generation and Graphical Representation of Tacfire Message Interoperability for Fire Support Automated Test System Software
Canh Vu	Sediment Bubbles

1992 Participants (cont'd)

Jon Ward	Remote Data Acquisition Sub-System (RDAS) Digital-to-Analog Converter (DAC)

1993 Participants

Catherine Baker	The Identification of Biologic Sounds in the Barents Sea
Sarah Benedict	Evaluation of Long-Baseline Differential Global Positioning System (LBDGPS) Accuracy for Determination of Free-Floating Buoy Positions
John Gonsoulin	Selection and Analysis of a Centrifugal Pump as a Representative Test Subject to Develop an Alternative Condition-Monitoring Process
Mica O'Brien	Extraction of High Frequency Transient Underwater Acoustic Signals
Alexander Roesler	Development of a Sound Velocity Profiler
Nathan Roesler	Transient Vibrations of Metallic Structures
Arturo Romanillos	Massively Parallel Computer
Travis Stiba	The Feasibility of Massively Parallel Computing for Beamforming and Signal Processing
Steven Sun	Diagnostic Analysis of Helicopter Gear Box Noise

Abstracts of Apprenticeship Reports

1. Mark Adkins. "Series Spark Gap Arrays," August 1992.

Underwater spark discharges have been utilized to generate broadband sound for years. In my research, I have sought to create an efficient linear transducer array using spark gaps connected in a series circuit with equal acoustic output and energy division among all gaps.

2. Erik Frank. "Testing and Evaluation of the Wesmar HD 670-8MCM Sonar System," August 1992.

This paper examines the performance characteristics of the Wesmar HD 670 sonar system, a small commercially available unit. The paper describes the process of testing the operating system, along with an analysis of the test results.

This paper is an evaluation of the sonar system's characteristics, its performance, and its overall effectiveness.

3. Scott Holliday. "Development and Testing of Stereo Sonar," August 1992.

Stereo sonar is the attempt to process sonar readings into 3D stereo images. The successful finished product would be a large array of two image sets which, when viewed separately for each eye, will appear as a 3D picture of the target as seen from a point above the horizontal plane.

4. Cassandra Jordan. "Graphical User Interface Development for the Fire Support Automated Test System," August 1992.

This report details the basic components of the Fire Support Automated Test System (FSATS) and the role of the graphical user interface in FSATS.

5. Steven Lefler. "Alternate Focusing Fluids for Use in Acoustic Target Spheres," August 1992.

It is the aim of this project to investigate possible alternative filling fluids for acoustic target spheres by measuring the speed of sound in several candidate fluids. Carbon tetrachloride, a carcinogen, was formerly used for its acoustical properties. An alternative fluid that has similar characteristics is desirable. GeneSolv D (Freon 113), a solvent provided by Allied Corp., mixed with isopropyl alcohol, has been investigated as an alternative. This investigation is an extension of the previous work by Boehme and Stockton and is aimed at identifying additional "environmentally friendly" alternative filling fluids with appropriate sound velocities.

6. Colby Leider. "Test Data File Generation and Graphical Representation of Tacfire Message Interoperability for Fire Support Automated Test System Software," August 1992.

Fire Support Automated Test System (FSATS) is an integrated software package currently being developed for the U.S. Army for the purpose of testing the Advanced Field Artillery Tactical Data System (AFATDS) and other such fire

support systems. The Tactical Message Translator (TMT) comprises a portion of the entire FSATS package and fits under its data reduction and analysis requirements. The TMT, still under development, can read, create, translate, edit, and verify messages. This paper deals in part with the creation of data files containing simulated messages which are needed to test the TMT.

Finally, the work presented here also deals with the generation of a graphical representation of all the messages that can be sent between any two given TACFIRE devices, based on version 10 of the Telos Fire Support System Interface Specification (FSSIS) manuals.

7. Canh Vu (with Tanya Wang, ARL:UT Honors Scholar). "Sediment Bubbles," August 1992.

In this report, the cause of the formation of underwater bubbles within sand sediment was sought. The system under study was a large chlorinated and pH controlled tank filled with sediment from Lake Travis. Bubbles within the sediment resonate and interfere with sonar detection of buried objects in sand.

Observation through forced penetration of the sediment were made to determine the typical volume and depth of the bubbles. Forced penetration was required since bubbles have not evolved on their own buoyancy. The average volume evolved was 15 ml at depths from 5 cm to 63.5 cm. Using gas chromatography, the bubble gas was found to be composed of 95% nitrogen and insignificant amounts of methane, oxygen, and carbon dioxide.

Ten gallon aquariums were set up to study possible causes and vary certain environmental factors. Initially, no bubbles were produced from any of the tanks. Introduction of nitrifying bacteria and fish food showed immediate results within one day. Crevices, presumed to be filled with nitrogen gas, and a darkening of the sand in a layer 8 cm below the water-bottom interface appeared.

Testing of the water in the aquariums and in the tank was also performed. The tests conducted were for nitrates, nitrites, chlorine, pH, and dissolved oxygen. An unusually high amount of nitrates was detected in the tank water, 140+ ppm. Nitrites were not found, except in a three-week-long refrigerated

aquarium and the aquariums with nitrifying bacteria. Chlorine levels varied from 1 to 3 ppm and pH varied from 6.8 to 7.2. Dissolved oxygen was present in large amounts, 8 to 10 ppm, for the tank and all aquariums.

Recommended further study included several new aquariums with many variables tested in new combinations, improved documentation and constant monitoring of the aquariums, and regular testing of the water for ions and bacteria. Concerning analyses of the gas, a better gas chromatograph able to analyze small amounts of gas is needed. Also, sand analysis and N^{15} tracing should be employed if possible.

8. Jon Ward. "Remote Data Acquisition Sub-System (RDAS) Digital-to-Analog Converter (DAC)," August 1992.

The Special Sonar Processor (SSP) is used to improve the capabilities of submarine-borne passive SONAR system by utilizing advanced signal processing algorithms. The Remote Data Acquisition Subsystem (RDAS) was designed to upgrade the existing SSP by reducing the total SSP system mechanical volume, cable routing requirements and installation complexity while increasing SSP system performance. It accomplishes this by upgrading the centralized 12-bit ADC front-end with remote 16-bit ADC subsystem and at the same time placing sufficient digital signal processing power in remote units to perform some preliminary processing, such as beamforming and filtering. The RDAS was also designed to use industry-standard interfaces and mechanical specifications throughout, thereby reducing the compatibility constrictions that would normally be encountered with MilSpec components.

The purpose of the Digital-to-Analog Card (DAC) in the RDAS is to provide a realtime aural output to the SONAR operators. The aural output is used because hearing the output is the primary method of identifying interesting SONAR signals. The DAC was designed with some initial specifications in mind. These specifications are: 4 channel 16-bit Digital-to-Analog conversion, >85 dB dynamic range, and low noise, low Total-Harmonic Distortion analog output.

The objective of this paper is to document the construction, evaluation, and testing of the RDAS Digital-to-Analog Converter board. In order to do this,

we will provide a functional description of the DAC board, test procedures, and results.

9. Catherine Baker. "The Identification of Biologic Sounds in the Barents Sea," August 1993.

The purpose of my project was to identify, via listening and computer-generated spectragrams, various species of marine mammals contributing to underwater ambient noise in the Arctic.

10. Sarah Benedict. "Evaluation of Long-Baseline Differential Global Positioning System (LBDGPS) Accuracy for Determination of Free-Floating Buoy Positions," August 1993.

My project consisted of evaluating the precision of Long-Baseline Differential Global Positioning System (LBDGPS) by processing International GPS Geodynamics Service (IGS) data and studying the solutions. The results will be used to determine the feasibility of applying LBDGPS to a task that Applied Research Laboratories, The University of Texas (ARL:UT), is currently working on. In doing so, I learned how to perform various types of data processing, especially Differential Global Positioning System (DGPS), using software such as ARL:UT Target Positioning Software package (ARLTPS) and Ashtech Incorporated's Multi-Site Mission Planning System. Furthermore, I became a more accomplished Internet user. I determined the location of IGS data bases, interacted with data administrators, and successfully identified and downloaded appropriate data.

11. John Gonsoulin. "Selection and Analysis of a Centrifugal Pump as a Representative Test Subject to Develop an Alternative Condition-Monitoring Process," August 1993.

At the beginning of the summer, I was assigned to complete the initial stage of an estimated two and a half year project. It was my responsibility to choose a test subject that would represent equipment commonly found in an industrial environment and would be conducive to an investigation into the possibility of designing an alternative method of monitoring industrial equipment.

12. Mica O'Brien. "Extraction of High Frequency Transient Underwater Acoustic Signals," August 1993.

The project I worked on during my time at ARL was to help the people here to further understand the signals received from the sonars. The signals that I used were obtained previously from a sea test off the coast of California. They were then brought here for further analysis. There were several processing techniques that I used in order to filter the signals and look closer at them. I used the Fast Fourier Transform, Short Time Fast Fourier Transform, frequency domain, time domain, and the time-frequency domain as ways of examining the signals. Then I used various FIR filters, time domain windowing, and a thresholding loop as ways of extracting the signals. At the end of it all we found the sources of many unidentified sounds. This could be used in the future in many ways. First of all, the sounds that I identified will be known from now on and can be used in the future to help with the speed of understanding the signals received from a sonar. The more sounds that we can identify, the faster and easier it will be use the sonar effectively.

13. Alexander Roesler. "Development of a Sound Velocity Profiler," August 1993.

Sound waves from underwater sonar devices are subject to many variations, primarily temperature, salinity, and depth. These variations affect the velocity of the underwater sound. Since the velocity of sound does not remain constant at all points, refraction (or bending) of the waves occurs. This refraction results in a nonlinear transmission of the sonar, as the sound waves tend to bend toward regions of lower velocity in accordance with the laws of geometrical optics. Due to this nonlinear transmission, negative effects occur within the sonar emissions, resulting in "gaps" in the sonar.

Using the sensor string, we can use the measurements we obtain for depth, salinity, and temperature to solve for the sound velocity at each five foot increment along the sensor string. By formatting and inputting this information into a MINERAY program, we can use MINERAY to determine a steering angle for the sonar that will minimize all negative results.

The sound velocity profile project was an overall success. All tasks were successfully achieved. Although we were able to store the data in a MINERAY compatible format, we were never able to use the data with the MINERAY program.

14. Nathan Roesler. "Transient Vibrations of Metallic Structures," August 1993.

The purpose of this project was to record the transient vibrations of simple metallic structures and to evaluate the data to determine the relationships between damping and frequency, and between acoustic signal and vibration. These can be very important parameters in signal detection and classification procedures for machinery condition monitoring.

15. Arturo Romanillos. "Massively Parallel Computer," August 1993.

Even as single processor technology has grown, so has multiprocessor technology. Currently there are several computers made up of 1024 processors which can run applications composed of several millions of pieces of information. Parallel processing has met the current need for computing power, but new applications arise every day that grow larger and larger.

16. Travis Stiba. "The Feasibility of Massively Parallel Computing for Beamforming and Signal Processing," August 1993.

Massively parallel computing is based upon the notion that certain problems and algorithms can be broken down into many distinct, somewhat independent processes. Each of these individual processes is then assigned to its own CPU. Banks of CPUs in parallel each have one problem to work, and can then give the output back to the grander scheme of the problem. This enables a large problem to be worked in a fraction of the time that a single processor could have done it.

Applications such as fluid mechanics, structural analysis, and signal processing are ideal for massively parallel computing, not only because they are

computationally intense, but because of their repetitive natures. It is, of course, signal processing and its nature that is dealt with at ARL.

In the science of signal processing, a method known as beamforming has become a standard. Beamforming mathematically gives a preference for sound in a particular direction while reducing the sounds coming from other directions. In order to do this, beamforming requires an array of input receivers (micro- or hydrophones) to detect a sound source. By having an array of several phones, the sound reaches each phone at a slightly different time. The array sensor outputs are delayed such that the signals from a given direction sum into phase (i.e., constructively add) and signals from other directions add out of phase (i.e., destructively interfere). Many look directions must be used to span the region of interest, and since calculating the beam noise for each look direction is very repetitive in nature, massively parallel computing could prove to be a very useful tool in this arm of signal processing.

17. Steven Sun. "Diagnostic Analysis of Helicopter Gear Box Noise," August 1993.

This article describes the procedure for simulating three-dimensional auditory information over headphones. The localization of acoustic signals was accomplished by filtering a monaural through a set of head related transfer functions. Since the objective of the project was to simulate a sonar operator's environment, the signal was masked by Guassian noise from all directions. The presence of noise also necessitated the need to find the threshold for signal detection.

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